Announcements

- Homework for tomorrow…

  Ch. 28, CQ 1 & 2, Probs. 6 & 36

  26.50: a) 3.6×10^3 N/C b) 9.6×10^{-3} m

  27.24: 1.8×10^{-8} C/m^2

  27.26: $E_1 = 900$ N/C, $E_2 = E_3 = 0$

- Office hours…

  MW 10-11 am

  TR 9-10 am

  F 12-1 pm

- Tutorial Learning Center (TLC) hours:

  MTWR 8-6 pm

  F 8-11 am, 2-5 pm

  Su 1-5 pm

Chapter 28

The Electric Potential

(*Potential Energy of Point Charges*)

Last time…

Work done by a *constant*, *variable* force…

$$\boxed{W = \vec{F} \cdot \Delta\vec{r}}$$

$$\boxed{W = \int_i^f \vec{F} \cdot d\vec{s}}$$

Potential energy defined…

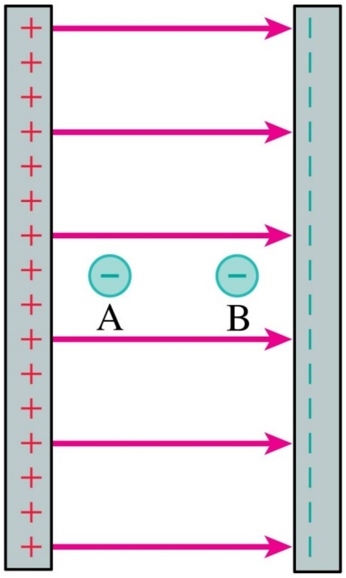
$$\boxed{\Delta U \equiv -W}$$

Potential energy of a charge *q* in a *uniform* *E*-field…

$$\boxed{U_{elec} = qEs}$$

Quiz Question 1

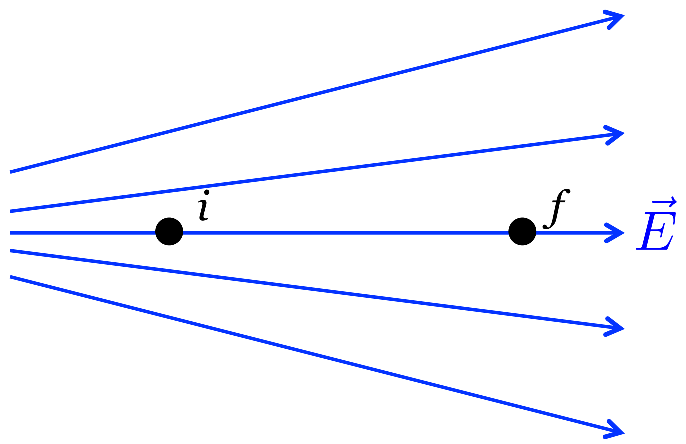
Two negative charges are equal.
Which has more electric potential energy?



1. Charge A.
2. Charge B.
3. They have the same potential energy.
4. Both have zero potential energy.

Quiz Question 2

A *positive* point charge is moved from *i* to *f* in the *non-uniform* *E*-field shown. During this process…

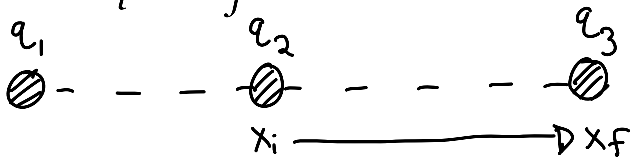


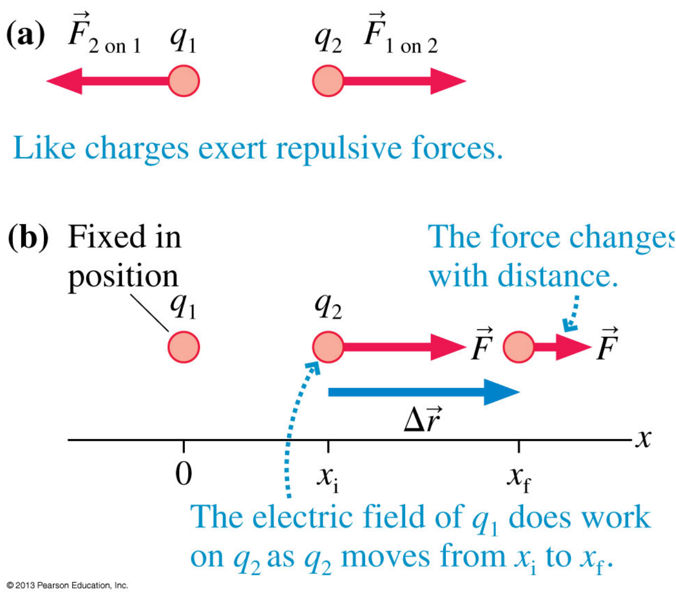
1. *E decreases, U increases, W* by the field is *negative*.
2. *E increases, U increases, W* by the field is *negative*.
3. *E decreases, U decreases, W* by the field is *negative*.
4. *E decreases, U decreases, W* by the field is *positive*.
5. *E is constant, U decreases, W* by the field is *positive*.

28.2: The Potential Energy of Point Charges

Calculate the…

1. *work done* by the E-field of q_1 on q_2
2. the *change in potential energy* of the system as q_2 moves from x_i to x_f.





$$\vec{F} = q_2 \vec{E}_1$$

$$\vec{E}_1 = \frac{Kq_1}{x^2}\,\hat{\imath}$$

$$dw_{elec} = \vec{F} \cdot d\vec{s} \qquad d\vec{s} = dx\,\hat{\imath}$$

$$= \frac{Kq_1q_2}{x^2}\,\hat{\imath} \cdot dx\,\hat{\imath}$$

$$= \frac{Kq_1q_2}{x^2}\,dx$$

$$W = \int_{x_i}^{x_f} \frac{Kq_1q_2}{x^2}\,dx \qquad \Delta u = u_f - u_i = \frac{Kq_1q_2}{x_f} - \frac{Kq_1q_2}{x_i}$$

$$= -Kq_1q_2 x^{-1} \Big|_{x_i}^{x_f}$$

$$W = \left[\frac{-Kq_1q_2}{x_f} + \frac{Kq_1q_2}{x_i} \right] = -\Delta u$$

The Potential Energy of Point Charges

The electric potential energy between two point charges is…

$$U_{elec} = \frac{K q_1 q_2}{r}$$

Potential Energy Between Two point Charges

$$U_E = \frac{K q_1 q_2}{r}$$

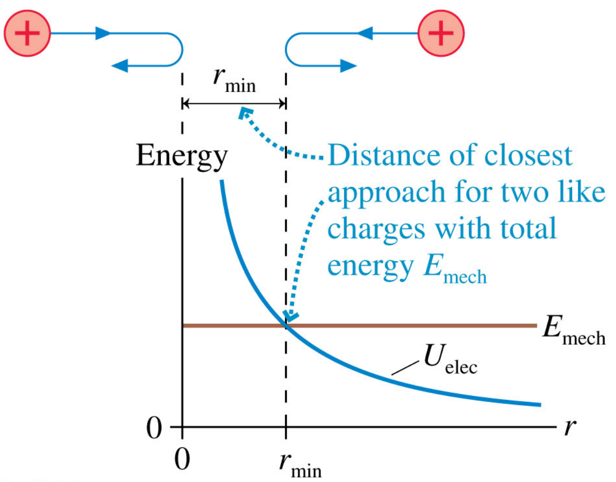
Notice:

- This is the potential energy *of a two charge system*.
- We've chosen the *zero point* of *U* at *r* ->∞.
- Potential energy of two *like* charges is *positive* and of two *opposite* charges is *negative*.
- Also holds for *uniform sphere of charge*.

Mechanical Energy Conservation…

- The total energy, E_{mech} , is a horizontal line because mechanical energy is *conserved*.
- When $E_{mech} > 0$, *unbounded system*.
- $E_{mech} = U_{elec}$ at $r = r_{min}$, where $K = 0$.
  - r_{min} is the *distance of closest approach* (a *turning point*).

(a) Like charges

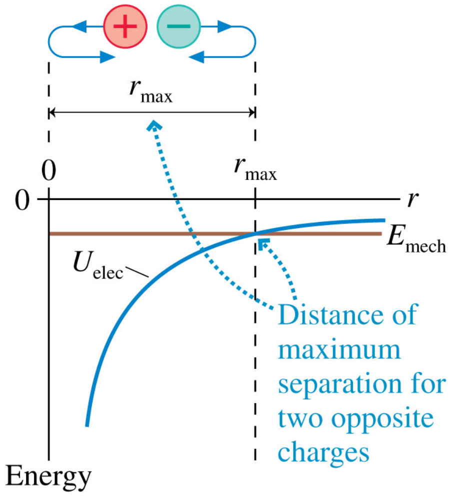


© 2013 Pearson Education, Inc.

Mechanical Energy Conservation…

- The total energy, E_{mech} , is a horizontal line because mechanical energy is *conserved*.
- When $E_{mech} < 0$, *bound system*.
- $E_{mech} = U_{elec}$ at $r = r_{max}$, where $K = 0$.
  - r_{max} is the *maximum separation distance* (a *turning point*).

(b) Opposite charges



© 2013 Pearson Education, Inc.

Quiz Question 3

A positive and a negative charge are released from rest in vacuum. They move toward each other. As they do:

1. A *positive* potential energy becomes *more positive*.
2. A *positive* potential energy becomes *less positive*.
3. A *negative* potential energy becomes *more negative*.
4. A *negative* potential energy becomes *less negative*.
5. A *positive* potential energy becomes a *negative* potential energy.

i.e. 28.3:
Escape velocity

An interaction between two elementary particles causes an electron and a positron (a positive electron) to be shot out back to back with equal speeds.

What minimum speed must each have when they are 100 fm apart in order to escape each other?

$V_{ie_-} = V_{ie_+}$

$r_{min} = 1.0 \times 10^{-13}\, m$

To escape each other?

$\lim_{r \to \infty} \quad V_F \to \emptyset$

$$K_0 + U_0 = \cancel{K_1}^{\,0} + \cancel{U_1}^{\,0}$$

$$\tfrac{1}{2}mv_0^2 + \tfrac{1}{2}mv_0^2 - \frac{Ke^2}{r_{min}}$$

$$mv_0^2 = \frac{ke^2}{r_{min}}$$

$$V_0 = \left(\frac{Ke^2}{r_{min}(m)}\right)^{1/2}$$

Multiple Point Charges

What is the *electric potential energy* of 3 pt charges?